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ABSTRACT

Results of a minimum competency test administered to ninth-grade students were evaluated to compare the performance of 723 students (345 males, 347 females, and 31 unidentified students) on content-specific and process skill questions. Subjects represented a random sample of students taking the Regents Competency Test in Science--a 70-item paper-and-pencil examination that is administered to students at the end of the ninth grade based on courses studied in grades 7, 8, and 9. The boys scored significantly better than did the girls in all subject areas. The passing rate for the boys was 88.4% and that for the girls was 77.8%. Both groups performed about the same when answering questions requiring process skill application without content knowledge, but female students appeared to have greater difficulty correctly answering questions that required integration of content knowledge and process skills. It may be that the everyday experiences of male students provide sufficient opportunity for boys to learn to apply the science skills they have acquired. (Author/SLD)

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PERFORMANCE OF NINTH GRADE MALES AND FEMALES ON A MINIMUM COMPETENCY TEST IN SCIENCE

(Paper presented at the 1990 AERA Annual Meeting in Boston, Massachusetts)

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Abstract

The results of a minimum competency test administered to ninth grade students was evaluated to compare the performance of male and female students on content specific and process skill questions. Boys scored significantly better than girls in all subjects areas. Both groups performed about the same when answering questions requiring process skill application without content knowledge, but female students appear to have greater difficulty correctly answering questions that require the integration of content knowledge and process skills.

Introduction

By the time they graduate from high school, males and females demonstrate significant differences in achievement in science, differences that did not exist when the students were in elementary (grades K through 6) and middle school (grades 6 through 8). While some research studies show no difference in science achievement among 13-year-olds (Lapointe et al., 1989; Haertel et al., 1981), others have found significant achievement differences among students in the ninth grade (Jacobson et al., 1987) and in late adolescence (Zerega et al.,1986). The data suggest that experiences in the junior high school years (grades 7 through 9) may play a pivotal role in the future science achievement of female students.

By the end of the ninth grade, the physical sciences seem to be the most difficult for students of both sexes, but particularly for girls (Jacobson, et al., 1987). Items dealing with motion, orbiting satellites, and energy require greater amounts of abstract thinking than those in the life and earth sciences. It is also more likely that boys will have first hand experience with machines and tools, providing them with a concrete base on which to build abstract concepts. As a result, it is expected that boys will out perform the girls in this area.

Other studies have found that girls are more likely to be passive observers in science activities that require manipulation of materials (Kahle & Lakes, 1983) resulting in their being less able to successfully carry out an experiment. As a result it may be more difficult for female students to acquire the process skills or to apply those process skills in content specific situations (Golbeck, 1986).

Purpose

The purpose of this study was to evaluate student success on the RCT based

on gender and science content areas.

Method

New York State has instituted a requirement that all students demonstrate minimum competency in science prior to receiving a high school diploma as of June 1991. One way for students to satisfy this requirement is to pass the Regents Competency Test in Science (RCT), which was administered for the first time in June 1988. The RCT was developed for students who are working towards a local high school diploma rather than following the Regents diploma track. Most of the students taking the RCT will terminate their formal education at the end of the twelfth grade.

The Regents Competency Test in Science is administered at the end of the ninth grade and is based on the science courses studied by students of both sexes in grades seven, eight and nine. Emphasis is on hands-on activities and real world applications through technology.

The syllabi on which the test is based are process oriented and focus only on the broad ideas of science, not the specific factual content with which most of us are familiar. The test is designed to assess those science skills considered necessary for a scientifically literate person, so that every high school graduate will be able to understand the scientific and technological issues facing our world and to make informed decisions concerning those issues. Questions on the test focus on broad understandings in life, physical and earth science and on process skills, rather than factual knowledge that is often memorized without understanding.

The RCT is a 70-item paper and pencil examination. The test analyzed for this study consisted of sixty-eight multiple-choice questions (four choices) and two free-response items, one requiring students to construct a graph of data and

the other asking students to predict the outcome of an experiment. Seventeen questions were from life science, fifteen from earth science, sixteen from physical science, six from technology, and sixteen from process skills (one process skill question was also keyed to physical science, but is grouped here for analysis purposes). Each question was keyed to the specific syllabus topic and/or process skill to which it relates by the committees developing the questions and the examination.

The questions are based on core understandings and process skills as outlined in the Middle/Junior High School Science Syllabus. This syllabus actually consists of 10 booklets called Blocks A through J. Blocks A, B, and C are life science; D,E, and F, earth science; G,H and I, physical science; and BLock J is a technology block that provides information for integrating technological understandings into the topics identified in the other blocks. Each Block contains a list of twenty-three process skills, sixteen of which have been identified as Core Process Skills and which are testable on the RCT. These skills are listed in Table I.

Answers to each of the seventy questions, the overall test score, and the gender of each student were recorded. Fifteen percent of the papers had the student's gender recorded on them. Gender for the remaining students was determined by first name. Item difficulties, mean scores, and passing percentages were determined for the whole group and for each gender. Questions were then grouped by science content area and process skills. Mean scores for each gender in each subgroup were then compared. T-tests comparing gender differences were done for each question, for the passing rate, and for the subgroups. The number of cases reported for each question may vary since some answers were left blank by a few students.

Subjects

The students taking the test in 1988 were mainly enrolled in a general science course. The majority of students taking the test were below average in academic performance.

Of the 88,789 papers written, approximately 15,000 RCT answer sheets were submitted to the State Education Department for regrading. The schools submitting these papers were selected by school type, size and geographic location data. From these 15,000 papers, a random sample of 723 papers was drawn. The sample included 345 males, 347 females and 31 unidentified students.

The passing rate for all RCT students statewide was 80.7%, while the passing rate for students in this sample of 723 was 82.6%. The difference can be accounted for by the fact that the percentage of papers from large city school districts called in for regrading was lower than the percentage of students in large city schools who took the test. Students in large city schools tend to have lower passing rates, resulting in a higher than expected passing rate for the sample.

Results

To pass the examination, students had to achieve a score of 46 or better out of a possible 70 points. The passing rate for the boys (88.4%) in the sample was significantly higher ($\alpha < .005$) than for the girls (77.8%). In addition, 75.9% of the boys scored higher than 50 on the test, while only 63.1% of the girls scored above 50 points. 38.3% of the boys scored over 60 compared to only 17.6% of the girls.

Males outperformed females on all subgroups, scoring significantly higher on the life, earth, and physical science questions ($\alpha < .001$) and technology questions ($\alpha = .001$). While the difference in performance on process skill

questions is not as drastic as for content areas, males still performed significantly better than females ($\alpha < .03$). Earth and physical science and technology were found to be the most difficult areas for all students, while life science was the easiest. Mean scores for these subgroups are shown in Table II.

Boys performed significantly better ($\alpha << .05$) on six life science questions, nine earth science questions, six physical science questions, two technology questions and four process skills questions. For two life science, six earth science, five physical science, one technology, and two process skill questions, more than ten percent fewer female students than male students responded correctly. The greatest discrepancy in performance occurred for questions dealing with weather, simple machines and electricity. (See Table III.) The electricity question (# 47) asked students to choose the best conductor given a choice of glass, rubber, plastic, or copper. Only 65.7 % of the girls could answer this question correctly compared to 83.5% of the boys.

The most difficult items on the test were from earth science. For example, only 49.1% of the students knew that high-and low-pressure areas generally move from west to east across the United States. Based on the key correlating exam questions to the syllabi, for two earth science, one life science, one physical science, three technology, and three process skill questions, less than 65% of the students answered correctly. However, two of the process skill questions required students to have specific earth science content knowledge (questions 33 and 35) and one required physical science content knowledge (question 34) to be answered correctly. A summary of these results are shown in Table IV and the three process skill questions are shown in Table VI.

There was one item on the test on which female students significantly ($\alpha = .04$) out performed male students. This item was a free response question in which students were shown diagrams representing four steps in an activity and

asked to predict what would happen in the fifth step. The question was keyed to both physical science and process skills, and was answered correctly by 87% of the girls and 81% of the boys. This question is shown in Table VI.

Discussion

The significant differences in performance between the boys and the girls raise many questions. It is not known if the students of both sexes represent students of equal average academic ability. Girls generally demonstrate greater success in school in terms of grades achieved. Enrollment data indicate that a slightly higher percentage of girls than boys (52% versus 48%) are enrolled in Regents earth science in the eighth and ninth grades and, therefore, would not take the RCT. However, this sampling bias is too small to explain the drastic difference in performance between males and females.

The relative difficulty of the earth science items may be partially explained by the students' lack of preparation in that area due to recent curriculum changes. Earth science concepts were not taught in many New York schools until the announcement of the RCT. As a result, the poor performance of students on those questions may be accounted for in large part by the lack of experience of teachers in this subject area and the lack of familiarity of students with those concepts. Of the nine earth science questions on which boys performed significantly better than girls, six questions were knowledge questions requiring factual recall. It appears than males were either better able to acquire this knowledge or are better at taking educated guesses than females. Similarly, the technology topics are relatively new, though conclusions are difficult to draw since only six technology items appear on the test.

The RCT questions are based on content covered in three years of junior high school science. Life science tends to be the most well understand area of

science for students in these grades and the science with which teachers are most comfortable. Therefore, it is not surprising that questions from life science would be the easiest for the students. What is interesting about the results is that the overwhelming majority of the students studied life science in seventh grade. Even though the test was not administered for two more years, students still performed better on those questions than on questions from subject areas studied more recently. About half the students studied earth science in eighth grade and physical science in ninth grade, while the pattern was reversed for the other half who studied physical science in grade eight.

A total of thirty-six items on the test involved the interpretation of a graph or diagram and two required the interpretation of data in a data chart. To correctly interpret these visual aids and utilize the information they provide to obtain the correct answers required students to use certain process skills (shown in Table I). On fourteen of these questions, boys performed significantly better than the girls ($\alpha < .05$). Of those fourteen questions, four items are keyed to life science; three, earth science; two, physical science; one, technology; and four, process skills. On one process question (also keyed to physical science), girls preformed significantly better ($\alpha = .04$) than the boys. A possible explanation is that this was the question on which students had to write a prediction of the fifth step in an experiment based on diagrams representing the preceding four steps. Girls tend to have better verbal skills than boys. See Table VI, question number 68.

Thirteen of the process skill questions involved a diagram, chart or graph which was needed to correctly answer the question, but only five of those questions showed significant differences in performance and on one of those five the girls did better than the boys. Two of the process questions which showed significant differences in achievement favoring the boys required specific

content knowledge to be answered correctly and, in the opinion of the author, should have been keyed as both content and process skill items. Questions 33 and 38 (shown in Table VI) illustrate the differences in these two types of process skill questions. While students can answer question 33 by simply reading a point on the graph with no specific science content knowledge, students must understand certain weather concepts to correctly answer question 38.

Of the twenty-five content specific items requiring analysis of a diagram, graph, or data chart, boys performed significantly better than the girls on eleven questions with no difference in performance on the other fourteen. It should be noted that for three of those remaining fourteen questions, student results were very poor with the percentage of students answering the questions correctly only 54%, 50%, and 63%. These results seem to indicate that the use of a diagram or other visual aid does not in and of itself impair the ability of females to correctly answer questions. Rather, it appears that girls have greater difficulty than boys with questions that require students to integrate their previously acquired content knowledge with the application of certain process skills. This result supports Golbeck's (1986) conclusion that females may have acquired the process skills but have difficulty using them in a content specific context. A summary of these results appears in Table V.

Educational Importance

The items that were found to be most difficult represent skills and content considered by science educators to be important for students of both sexes to master. Improving the students' ability to correctly answer these questions may require alternative teaching strategies since the traditional teaching methods have been unsuccessful.

Teaching practices must focus on developing ways to increase active female

participation in the sciences, stressing the need for girls to physically manipulate equipment and carry out experiments. By having opportunities to work with concrete objects, students can develop a strong fundamental understanding of concepts and will have concrete experiences to fall back on as they try to interpret abstract representations of those concepts. Mastery of process skills is important since those skills apply in many different contexts. However, it is necessary for teachers to provide students with opportunities to use those skills in content related ways. It may be that the everyday experiences of male students provide sufficient opportunities for boys to apply the skills they have acquired, but it appears that either such opportunities are not sufficiently available to female students or girls may need more direction in learning how to apply their skills.

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TABLE I

Core Process Skills That Are Testable on the RCT

Planning and Design

1.2 Predicts an experimental result

1.4 Designs an observation or measurement procedure

1.5 Designs a controlled experiment

Performance

2.1a Carries out a qualitative observation

2.1b Carries out a quantitative observation or measurement

2.2 Manipulates apparatus safely; develops technique

2.3 Records results; describes observations

2.4 Performs numeric calculations

2.5 Explains or makes a decision about experimental technique

Analysis, Interpretation, and Application

3.1a Transforms results into a standard form (other than graphs), such as a data table where the form is given

3.1b Graphs data, given numbered axes

3.2a Determines a qualitative relationship

3.2b Determines a quantitative relationship

3.6a Interprets data in graphs, tables, and diagrams

3.6b Explains a relationship

3.8 Predicts based on the results of the investigation

TABLE II

Summary of Performance by Gender for Each Subgroup

Subgroup/ Maximum Score	Gender	Number of Cases	Mean Score	Standard Deviation	t value	2-tail Prob.
Life Science 17	Male Female	343 346	16.21 15.51	2.51 2.51	3.67	<.001
Earth Science 15	Male Female	343 346	11.69 10.50	2.46 2.58	6.16	<.001
Physical Science 16	Male Female	345 345	12.64 11.49	2.88 2.80	5.31	<.001
Technology 6	Male Female	343 341	4.45 4.11	1.34 1.33	3.29	.001
Process Skills 16	Male Female	332 338	12.88 12.47	2.48 2.31	2.22	.027

TABLE III

Questions Showing the Greatest Discrepancy in Performance Between Male and Female Students

Question/ Topic *	Gender	Number of Cases	% Answering Correctly	t value	2-tail Prob.
48 Machines	Male Female	345 347	78.3 58.8	5.63	<.001
47 Electric.	Male Female	345 347	83.5 65.7	5.48	<.001
33 Weather	Male Female	345 347	68.1 51.3	4.57	<.001

* See Table IV for actual questions.

TABLE IV

Questions Which Less Than 65% of the Students Answered Correctly

Subject Area	Question Number	% Answering Correctly
Life Science	10	59.4
Earth Science	29	49.1
	42	50.2
Physical Science	50	58.7
Technology	61	63.6
	64	62.9
	65	60.5
Process Skills	33 *	62.9
	34 *	43.2
	35 *	53.9

* Require specific content knowledge to answer.

TABLE V

Questions Requiring Integration of Process Skills and Content Knowledge Which Showed Significant Performance Differences Between Males and Females

Subject Area/ Question	Gender	Number of Cases	% Answering Correctly	t value	2-tail Prob.
Life Science 4	Male	345	85.2	2.15	.032
	Female	347	79.0		
Life Science 6	Male	345	83.2	2.42	.016
	Female	347	75.8		
Life Science 10	Male	345	64.6	3.27	.001
	Female	347	52.5		
Life Science 18	Male	345	89.0	2.47	.014
	Female	347	82.4		
Earth Science 23	Male	345	85.2	3.67	<.001
	Female	347	74.1		
Earth Science 31	Male	345	81.7	2.35	.019
	Female	347	74.4		
Earth Science 40	Male	345	77.4	2.12	.034
	Female	347	70.3		
Physical Sci. 46	Male	345	79.7	3.53	<.001
	Female	347	68.0		
Physical Sci. 48	Male	345	78.3	5.63	<.001
	Female	347	58.8		
Technology 65	Male	345	64.6	2.62	.009
	Female	346	54.9		
Process Skill 33 *	Male	345	68.1	4.57	<.001
	Female	347	51.3		
Process Skill 34 *	Male	344	50.3	3.03	.003
	Female	347	38.9		
Process Skill 41	Male	345	81.7	4.32	<.001
	Female	346	67.6		
Process Skill 63	Male	344	89.2	2.28	.023
	Female	347	83.3		
Process Skill 68 +	Male	340	80.9	-2.06	.040
	Female	345	86.7		

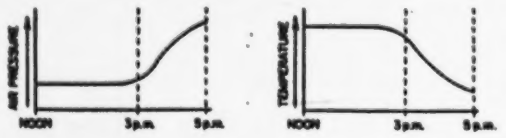
* Require specific content knowledge to answer.

\+ Also keyed to physical science; content knowledge is required to answer.

Table VI

Sample Questions

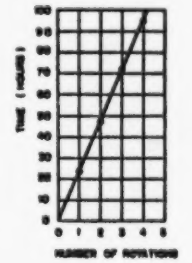
33 At a weather station in New York State, the air pressure and temperature were recorded from noon to 5 p.m. on the same day. The data are shown in the graphs below.



Which change occurred at this weather station at 3 p.m.?

(1) The season changed.
(2) A front passed by.
(3) Temperature increased.
(4) Air pressure decreased.

38 According to the graph below, how many hours does Earth take to complete $2\frac{1}{2}$ rotations?



(1) 1.0 hour
(2) 0.1 hour
(3) 36 hours
(4) 60 hours

Note that question 34 has only three choices.

34 The diagram at the right shows an activity in which a large open can full of air is placed on a balance. The can is removed, heated, and placed on the balance again. Which diagram below shows how the balance most likely will look just after the can is heated?

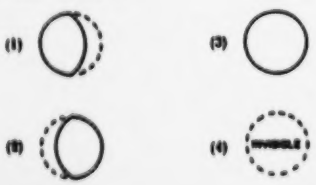
48 The picture below shows the shadows of a girl, a rock, and a tree. The girl is in New York State and the time is noon.

In which direction is the girl facing?

(1) north
(2) south
(3) east
(4) west

35 A student observed the Moon on five different nights in May. The diagrams below represent how the Moon appeared.

How will the Moon appear on May 30?



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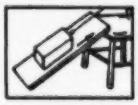
47 Which material is a good conductor of electrical energy?

(1) glass
(2) rubber
(3) plastic
(4) copper

48 Which diagram shows a lever in use?

(1) 

(2)

(3)

(4)

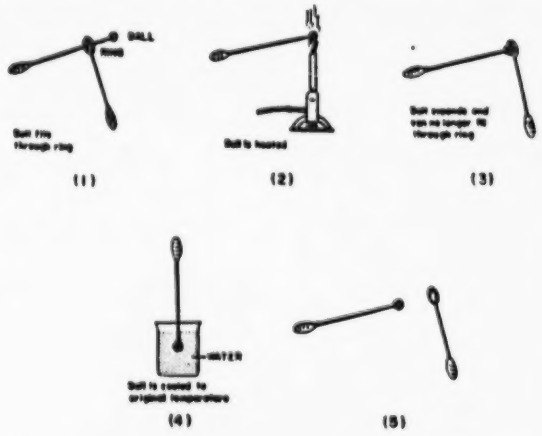
49 Which statement best describes the energy change shown in the diagram below?

(1) Electrical energy is changed to heat energy and light energy.
(2) Heat energy is changed to electrical energy and light energy.
(3) Light energy is changed to electrical energy and heat energy.
(4) Heat energy and light energy are changed to electrical energy.

Directions (68–70). Record your answers for questions 68 through 70 in the spaces provided on the last page of this test booklet. Turn to the last page and fold it along the dotted line. Then tear it off slowly and carefully. Write your name and the other information requested in the spaces at the top of the page.

Read questions 68, 69, and 70 carefully. Record your answer for each question according to the directions given in the question.

68 Diagrams 1 through 5 below show the steps in an activity to find out the effect of heat on a metal ball.



Predict what will happen in step 5 when a student again tries to fit the ball through the ring. Write your answer on the lines provided on your answer sheet.

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